EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2488	EAM or (electro adj absorption)	US-PGPUB; USPAT	OR	ON	2006/11/02 14:28
L2	799	1 and quantum	US-PGPUB; USPAT	OR	ON	2006/11/02 14:28
L3	24	2 and SiGe	US-PGPUB; USPAT	OR	ON	2006/11/02 14:28
L4	19	3 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 14:35
L5	596	2 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 15:55
L6	577	5 not 4	US-PGPUB; USPAT	OR	ON	2006/11/02 14:35
L7	352	6 and contact	US-PGPUB; USPAT	OR	ON	2006/11/02 14:36
L8	338	7 and light	US-PGPUB; USPAT	OR	ON	2006/11/02 14:36
L9	302	8 and modulator	US-PGPUB; USPAT	OR	ON	2006/11/02 15:17
L10	8	9 and Ge	US-PGPUB; USPAT	OR	ON	2006/11/02 15:35
L12	11	(modulator and (light or optical) and quantum and Ge and contact).clm.	US-PGPUB; USPAT	OR	ON	2006/11/02 15:20
L13	10	12 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 15:22
L14	7	(modulator and (light or optical) and quantum and (Si near5 Ge) and contact).clm.	US-PGPUB; USPAT	OR	ON	2006/11/02 15:21
L15	7	14 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 15:20
L16	253	(modulator and (light or optical) and quantum and (Si near5 Ge) and contact)	US-PGPUB; USPAT	OR	ON	2006/11/02 15:22
L17	67	modulator and (light or optical) and (quantum same (Si near5 Ge)) and contact	US-PGPUB; USPAT	OR	ON	2006/11/02 15:22
L18	47	17 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 15:22
L21	194	(intel or (donald with S with gardner)) and SiGe	US-PGPUB; USPAT	OR	ON	2006/11/02 15:58
L22	59	21 and quantum	US-PGPUB; USPAT	OR	ON	2006/11/02 15:58

EAST Search History

L23	38	22 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 16:14
L24	29	(intel or (donald with S with gardner)) and SiGe	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/11/02 15:58
L25	0	24 and quantum	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2006/11/02 16:13
L26	24	(optical with modulator) and (strained with SiGe) and quantum and fiber	US-PGPUB; USPAT	OR	ON	2006/11/02 16:17
L27	18	26 and @ad<"20031231"	US-PGPUB; USPAT	OR	ON	2006/11/02 16:14
L28	1	((optical with modulator) and (strained with SiGe) and quantum and fiber).clm.	US-PGPUB; USPAT	OR	ON	2006/11/02 16:18

DOCUMENT-IDENTIFIER: US 20040126072 A1

TITLE: Optical devices with engineered nonlinear nanocomposite materials

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Summary of Invention Paragraph - BSTX (29):

[0027] In another embodiment, the optical device comprises a waveguide core including a portion formed of a nanocomposite material. The nanocomposite material includes a matrix material and a plurality of quantum dots dispersed in the matrix material. A quantum dot of the plurality of quantum dots includes a core that includes a semiconductor material selected from the group consisting of Si and **Ge, and the quantum** dot is substantially defect free such that the quantum dot exhibits photoluminescence with a quantum efficiency that is greater than 10 percent.

Detail Description Paragraph - DETX (56):

[0119] FIGS. 1(a), 1(b), 1(c), and 1(d) illustrates quantum dots according to some embodiments of the invention. In particular, FIG. 1(a) illustrates a quantum dot 100 comprising a core 102, according to an embodiment of the invention. A core (e.g., the core 102) of a quantum dot may comprise inorganic crystals of Group IV semiconductor materials including but not limited to Si, **Ge,** and C; Group II-VI semiconductor materials including but not limited to ZnS, ZnSe, ZnTe, ZnO, CdS, CdSe, CdTe, CdO, HgS, HgSe, HgTe, HgO, MgS, MgSe, MgTe, MgO, CaS, CaSe, CaTe, CaO, SrS, SrSe, SrTe, SrO, BaS, BaSe, BaTe, and BaO; Group III-V semiconductor materials including but not limited to AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, InP, InAs, and InSb; Group IV-VI semiconductor materials including but not limited to PbS, PbSe, PbTe, and PbO; mixtures thereof; and tertiary or alloyed compounds of any combination between or within these groups. Alternatively, or in conjunction, a core can comprise a crystalline organic material (e.g., a crystalline organic semiconductor material) or an inorganic and/or organic material in either polycrystalline or amorphous form.

Detail Description Paragraph - DETX (57):

[0120] A core may optionally be surrounded by a shell of a second organic or inorganic material. FIG. 1(b) illustrates a quantum dot 104 according to another embodiment of the invention. Here, the quantum dot 104 comprises a core 106 that is surrounded by a shell 108. A shell (e.g., the shell 108) may

comprise inorganic crystals of Group IV semiconductor materials including but not limited to Si, **Ge,** and C; Group II-VI semiconductor materials including but not limited to ZnS, ZnSe, ZnTe, ZnO, CdS, CdSe, CdTe, CdO, HgS, HgSe, HgTe, HgO, MgS, MgSe, MgTe, MgO, CaS, CaSe, CaTe, CaO, SrS, SrSe, SrTe, SrO, BaS, BaSe, BaTe, and BaO; Group III-V semiconductor materials including but not limited to AlN, Alp, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, InP, InAs, and InSb; mixtures thereof; and tertiary or alloyed compounds of any combination between or within these groups. Alternatively, or in conjunction, a shell can comprise a crystalline organic material (e.g., a crystalline organic semiconductor material) or an inorganic and/or organic material in either polycrystalline or amorphous form. A shell may be doped or undoped, and in the case of doped shells, the dopants may be either atomic or molecular. A shell may optionally comprise multiple materials, in which different materials are stacked on top of each other to form a multi-layered shell structure.

Detail Description Paragraph - DETX (181):
[0239] There are a variety of preferred quantum dot materials for some embodiments of the current invention. For any given application, the preferred materials can be determined based on the specific optical requirements for that application. Examples of such preferred materials include but are not limited to inorganic crystals of Group IV semiconductor materials including but not limited to Si, **Ge,** and C; Group II-VI semiconductor materials including but not limited to ZnS, ZnSe, ZnTe, ZnO, CdS, CdSe, CdTe, CdO, HgS, HgSe, HgTe, HgO, MgS, MgSe, MgTe, MgO, CaS, CaSe, CaTe, CaO, SrS, SrSe, SrTe, SrO, BaS, BaSe, BaTe and BaO; Group III-V semiconductor materials including but not limited to AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, InP, InAs and InSb; Group IV-VI semiconductor materials including but not limited to PbS, PbSe, PbTe, and PbO; mixtures thereof; and tertiary or alloyed compounds of any combination between or within these groups, including but not limited to GeSe, SnS, SnSe, PbS, PbSe, PbTe ZnGeAs.sub.2, ZnSnP.sub.2, ZnSnAs.sub.2, CdSiAs.sub.2, CdGeP.sub.2, CdGaAs.sub.2, CdSnP.sub.2, and CdSnAs.sub.2.

Detail Description Paragraph - DETX (184):
[0242] Two preferred materials for use in quantum dots are silicon and germanium, according to some embodiments of the invention. Both Si and **Ge** have bulk energy gaps that are less than 1.6 eV, making them ideal materials from which to fabricate quantum dots that exploit quantum confinement to enhance optical nonlinearities at telecommunications wavelengths (where photon energies are typically .about.0.8 eV). The ideal chemistry of Group IV materials (as discussed below) further solidifies these choices.

Detail Description Paragraph - DETX (185):

[0243] In addition, the electron affinity or ionization potential of Group IV materials (e.g., Si and **Ge**) makes them amenable to forming strong and stable covalent bonds with organic and inorganic surface ligands, making them ideal for this purpose and for enabling quantum dots that are stable in ambient as well as reasonably extreme environmental conditions. The significance of this capability can be better appreciated by recognizing that the surfaces of quantum dots comprised of more ionic materials often require surfactants or ionic species to cap, which involves less preferable and weaker van der Waals bonds, hydrogen bonds, or ionic bonds. Examples of these more ionic quantum dot materials include Group II-VI materials such as CdSe. These more ionic quantum dots often require complex processing to modify the ionic quantum dots so as to enable the more desirable covalent bonding between the quantum dot surface and surface ligands, e.g., a surface layer or layers comprised of a material different than the core quantum dot material typically needs to be added to the ionic quantum dot surface, wherein the attached surface layer or layers are amenable to covalent bonding to surface ligands. An example of such a surface layer is one comprised of CdS.

Detail Description Paragraph - DETX (186):
[0244] In addition, the chemical properties of Group IV materials (e.g., Si and **Ge**) are such that a stable oxide can be formed that serves to confine carriers and to passivate the surface to mitigate surface traps.

Detail Description Paragraph - DETX (187):
[0245] In addition, the Bohr exciton is relatively large in **Ge** (.about.12 nm), thus providing a large size range over which the beneficial effect of quantum confinement, as discussed in various sections herein, are relevant.

Detail Description Paragraph - DETX (189):
[0247] In one embodiment, the quantum dots are silicon quantum dots or germanium quantum dots that are surface passivated (or terminated) with an inorganic layer (such as oxides of silicon and germanium) and/or organic and/or inorganic surface ligands, herein sometimes referred to as SiQDs and GeQDs, respectively. SiQDs and GeQDs as described herein are novel types of quantum dots that show definitive quantum confinement effects as manifested by size dependent properties such as size-dependent energy gaps that can be tuned over a very broad range and in particular from the near infrared to the near ultraviolet. In addition, SiQDs and GeQDs are stable under a variety of environmental conditions including ambient (e.g., pressure: .about.1 atmosphere; Gases: .about.70% nitrogen, .about.30% oxygen; Temperature: .about.20-25 C) for desired periods of time depending on the specific application. A SiQD and a GeQD can be comprised of a substantially Si core for

a SiQD and a substantially **Ge** core for a GeQD. In addition, the "surface" of the SiQD can be comprised of Si and inorganic elements such as oxygen and/or organic ligands (R). In addition, the "surface" of the GeQD can be comprised of **Ge** and inorganic elements such as oxygen and/or organic ligands (R).

Detail Description Paragraph - DETX (190):
[0248] In one embodiment of the invention, a SiQD comprises a substantially defect free silicon crystal core of diameter between approximately 1 nm and 100 nm, preferably between approximately 1 nm and 20 nm, more preferably between approximately 1 nm and 10 nm, while a GeQD comprises a substantially defect free germanium crystal core of diameter between approximately 1 nm and 100 nm, preferably between approximately 1 and 50 nm, more preferably between approximately 1 and 20 nm. In the case of an inorganic shell surrounding the silicon or germanium core, this shell typically has a thickness of between approximately 0.1 and 5 nm. One preferred inorganic shell is SIO.sub.n for SiQD and GeO.sub.n for GeQD with n ranging between approximately 0 and 2, preferably ranging between approximately 1.5 and 2, most preferably ranging between approximately 1.8 to 2. The chemical composition of the shell (e.g., relative amounts of Si (or **Ge**) and O) is potentially varying continuously through a portion of the shell and optionally varying discontinuously through a portion of the shell, in which case n can represent an averaged value within the shell. In the case of organic surface ligands terminating the surface, the SiQD and GeQD can comprise ligand layers comprising organic molecules with a structure R. R can be any one of a variety of hydrophobic, hydrophilic, or amphiphilic molecules (a list of preferred surface ligands is included below). The surface ligands can provide a surface coverage of available silicon (or germanium) and oxygen binding sites at the surface to provide between approximately 0% and 100% surface coverage, preferably between approximately 20% and 100% surface coverage, more preferably between approximately 50% and 100% surface coverage, more preferably between approximately 80% and 100% surface coverage, with a maximum of one or more complete layers of surface ligands. R can optionally comprise a plurality of different organic molecules at a plurality of absolute and relative densities. Finally, a SiQD or GeQD may optionally comprise additional R-groups that do not interact directly with the quantum dot surface, but rather indirectly through other R-groups interacting directly with the surface. In this case, surface coverage greater than 100% is possible.

Detail Description Paragraph - DETX (192):
[0250] Methods for fabricating SiQDs and GeQDs in accordance with some embodiments of the invention are discussed below. It should be noted, however, that the current invention refers to SiQDs or GeQDs synthesized by a variety of

other methods in addition to those described herein. Some embodiments of the invention encompass various possible variations of composition of SiQD and GeQDs that could be made while retaining the general characteristics of a substantially crystalline Si or **Ge** core and a substantially noncrystalline inorganic (e.g., oxide) shell or organic ligand layer.

Detail Description Paragraph - DETX (214):
[0272] The defect-free nature of the resulting SiQDs is manifested in the quantum efficiency of the photoluminescence from these SiQDs. The presence of defects in quantum dots can trap excited carriers (electrons and holes). These trapped carriers can either nonradiatively relax, or they can radiatively recombine in a defect. Both processes lead to a low quantum efficiency for the photoluminescence from the quantum dots. Previous quantum dots formed of Si or **Ge** typically exhibited photoluminescence quantum efficiencies of .about.1-5%. In contrast, the photoluminescence quantum efficiency of the SiQDs made with the methods of some embodiments of this invention is greater than 6%, preferably at least or greater than 10%, more preferably at least 20%, more preferably at least 30%, more preferably at least 40%, and more preferably at least 50% (e.g., as high as between approximately 50% and 60%). This represents the largest photoluminescence quantum efficiency observed for such quantum dots.

Detail Description Paragraph - DETX (222):
[0280] The electronic and optical properties of these GeQDs that are made in this fashion are unique in that they show size dependent properties that are uniquely consistent with quantum confinement. The optical and electronic properties of these GeQDs are uniquely consistent with theoretical calculations more sophisticated than Effective Mass approaches, such as the Empirical Pseudopotential Method and the Tight Binding Method. A comparison of the size dependent energy gap calculated by these methods with measurements taken on the GeQDs synthesized by the method disclosed herein is shown in FIG. 4(a). The agreement is extremely good and is the best observed for any quantum dots formed of **Ge**.

Detail Description Paragraph - DETX (233):
[0287] wherein YX.sub.a is a source of Y, with Y being Si or **Ge,** and X is selected from the group consisting of --F, --Cl, --Br, --I, --O--CO--R.sup.(1), --NR.sup.(2)R.sup.(3), --O--R.sup.(4), --S--R.sup.(5), and so forth, with R.sup.(1), R.sup.(2), R.sup.(3), R.sup.(4), and R.sup.(5) independently selected from the group consisting of alkyls, alkenyls, alkynyls, aryls, and so forth. The reducing agent is selected from either activated metals (e.g., Group IA, Group IIA, transition metals, and lanthanides) or hydrides (Group

IIIB hydrides, Group IVB hydrides, and transition metal hydrides). Electrochemical reduction can also be used for reduction. The capping agent(R) and the capping agent(R') are sources of surface ligands R and R', respectively, and can be selected from organometallic reagents, e.g., RM (or R'M), with R (or R') being a surface ligand (e.g., a linear or branched alkyls, alkenyls, alkynyls, ether, ester, acid, amide or nitrile moiety having between 1 and about 20 carbon atoms). It should be recognized that the surface ligands R and R' can be the same or different. The capping agents can also be an alcohol, amine, thiol, and so forth. M is preferably from Group IA, Group IIA, or Group IIB. In the above, "a" represents an oxidation state or coordination number of Y in the source of Y, which is typically 2, 4, or 6, and "b" and "c" are integers that can each range from 1 to 6. "a" is typically equal to the sum of "b" and "c". In method 2-a, (Y)X represent intermediate particles comprising cores including Y and with surfaces terminated with X, and (Y)R represent quantum dots that are formed with surfaces terminated with R. In method 2-b, R(Y)X represent intermediate particles comprising cores including Y and with surfaces terminated with R and X, and R(Y)R' represent quantum dots that are formed with surfaces terminated with R and R'.

Detail Description Paragraph - DETX (234):
[0288] The basic strategy involves solution phase reduction of SI.sup.a+ or Ge.sup.a+, where a represents the oxidation state of Si or **Ge,** and subsequent termination with organic or organometallic reagents. The methods according to some embodiments of the invention allow mild synthesis, precise manipulation, functionalization, and interconnection of the Group IV quantum dots to an extent not previously achieved. The key differentiations between previously used methods and the methods according to some embodiments of the invention include one or more of the following:

Detail Description Paragraph - DETX (252):
[0306] In this process, a Group IV source, such as providing Si.sup.4+, Ge.sup.4+, or Ge.sup.2+, especially in the form of halides or with corresponding 1-20 carbon organic substituent (RA, R=organic substituent, A=O, S, N, Si, etc.), is reacted with a reducing agent, such as a Group IA compound, Group IIA compound, transition metal, lanthanide, or hydride, in liquid phase reaction medium at an elevated temperature. Representative Group IV sources include SiF.sub.4, SiCl.sub.4, SiBr.sub.4, SiI.sub.4, GeF.sub.4, GeCl.sub.4, GeBr.sub.4, GeI.sub.4, GeCl.sub.2, GeBr.sub.2, GeI.sub.2, SiR.sub.4, Si(OR).sub.4, Si(SR).sub.4, Si(NR.sup.(1)R.sup.(2)).sub.4, Si(O.sub.2R).sub.4, Si(SiR).sub.4, GeR4, **Ge**(OR).sub.4, **Ge**(SR).sub.4, **Ge**(NR.sup.(1)R.sup.(2)).sub.4, **Ge**(O.sub.2R).sub.4, **Ge**(SiR).sub.4 **Ge**(NR.sup.(1)R.sup.(2)).sub.2, as well as the dimmers and the higher oligomers of the above reagents (R, R.sup.(1),

R.sup.(2)=organic substituent). Representative reducing agents include Li, Na, K, Na/K alloy, Rb, Cs, Be, Mg, Ca, Sr, Ba, Sc, Ti, Zr, Mn, Fe, Co, Ni, Pd, Cu, Zn, Ce, Sm, Gd, Eu, LiAlH.sub.4, NaBH.sub.4, Super-hydride, L-Selectride, RSiH.sub.3, R.sub.2SiH.sub.2, R.sub.3SiH (R=organic substituent), and the like. Reducing agents can be provided in a variety of forms (e.g., as a powder, a liquid, a solid, and so forth). For certain reducing agents (e.g., a Group IIA compound such as, for example, Mg), it is desirable to provide such reducing agents in a powdered form to facilitate reaction with the Group IV source. Alternatively, or in conjunction, it is desirable to provide such reducing agents in other forms such as in the form of chips, a mesh, dendritic pieces, ribbons, rods, turning or activated (e.g., "Rieke magnesium", etc.).

Detail Description Paragraph - DETX (253):
[0307] One or two of each of these two groups of materials are mixed together in the reaction medium (e.g., an anhydrous aprotic solvent) for at least few minutes. For some embodiments, the reaction between a source of Si or **Ge** and a reducing agent is performed by maintaining the reaction medium at a temperature between approximately -78.degree. C. and 300.degree. C., preferably between approximately 60.degree. C. and 280.degree. C., and at around ambient pressure (e.g., about 1 atm) for a period of time between approximately 2 and 48 hrs. For some embodiments, the reaction between Na and silicon reagents can require an elevated temperature and a prolonged period to complete. The reflux temperature of the reaction medium can be used. Elevated pressures of up to about 100 atmospheres can be used to obtain higher temperatures. Suitable temperatures range between approximately 25 and 300.degree. C.

Detail Description Paragraph - DETX (294):
[0348] The following are preferred surface ligands of the ligand layer, according to some embodiments of the invention. This list, which is not intended to be exhaustive, describes a number of surface ligands having desirable physical characteristics that can be used to form ligand layers for SiQDs or GeQDs. In the following, Y is Si or **Ge**, and Y--C, Y--O, Y--S, Y--Si, and Y--N denote covalent bonds between Si or **Ge** and a C atom, an O atom, a S atom, a Si atom, and a N atom, respectively. Other preferred surface ligands, not listed below, can contain a P or a Se atom that is covalently bonded to Si or **Ge**.

Detail Description Paragraph - DETX (351):
[0405] FIGS. 10(a) and 10(b) show PL spectra of organic-terminated Si quantum dots, and FIGS. 11(a) and 11(b) show PL spectra of organic-terminated **Ge quantum** dots. The Si and **Ge quantum** dots were made with the methods

described herein. The PL spectra show that the light emission can be readily tuned from the red to the ultraviolet by exciting quantum dots of different sizes. The PL spectra are obtained by optically exciting the quantum dots with wavelengths shorter than the wavelength at the absorption edge of the quantum dots. This light emission is stable in ambient conditions. This stability is due in large part to the relative completeness and stability of the surface termination, e.g., the surface termination and the interface between the core and the surface termination is substantially defect free. In FIGS. 10(a) and 10(b), the surfaces of the Si quantum dots are terminated with 4-methoxyphenyl groups. In FIG. 10(b), the vertical axis represents a normalized photoluminescence signal from FIG. 10(a). In FIGS. 11(a) and 11(b), the surfaces of the **Ge quantum** dots are terminated with butyl groups. In FIG. 11(b), the vertical axis represents a normalized photoluminescence signal from FIG. 11(a). Similar results can be seen for Si quantum dots having surfaces terminated with ethoxy groups and **Ge quantum** dots having surfaces terminated with methyl groups.

Detail Description Paragraph - DETX (352):

[0406] The electronic and optical properties of these organic-terminated SiQDs and GeQDs that are made in this fashion are unique in that they show size dependent properties that are uniquely consistent with quantum confinement. The optical and electronic properties of these SiQDs and GeQDs are uniquely consistent with theoretical calculations more sophisticated than Effective Mass approaches, such as the Empirical Pseudopotential Method and the Tight Binding Method. A comparison of the size dependent energy gap calculated by these methods with measurements taken on the SiQDs and GeQDs synthesized by the method disclosed herein show that the agreement is extremely good and is the best observed for any quantum dot formed of Si or **Ge**.

Claims Text - CLTX (14):

13. An optical device comprising: a waveguide core including a portion formed of a nanocomposite material, said nanocomposite material including: a matrix material; and a plurality of quantum dots dispersed in said matrix material, a quantum dot of said plurality of quantum dots including a core that includes a semiconductor material selected from the group consisting of Si and **Ge, said quantum** dot being substantially defect free such that said quantum dot exhibits photoluminescence with a quantum efficiency that is greater than 10 percent.

US-PAT-NO: 6597011

DOCUMENT-IDENTIFIER: US 6597011 B1

TITLE: Dual non-parallel electronic field electro-optic effect device

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Brief Summary Text - BSTX (39):

The present invention is preferably for an active region comprising of multiple quantum wells using AlGaAs and InGaAs semiconductors. The electric fields are established via a single n-type dopant species in an attempt to make the said device compatible with MMIC processing. Other implementations such as using p-type and n-type layers are also possible. It should be noted that heterostructures from other group III-V (e.g. InGaAsP, InAlGaAs, and InP), II-VI (e.g. CdZnTe), IV-IV (e.g. **Si--Ge**), amorphous silicon compounds and rare-earth-doped Silicon may equally be applied to this technology.